1st Choice of Position Holders

UNIQUE NOTES

PHYSICS 10

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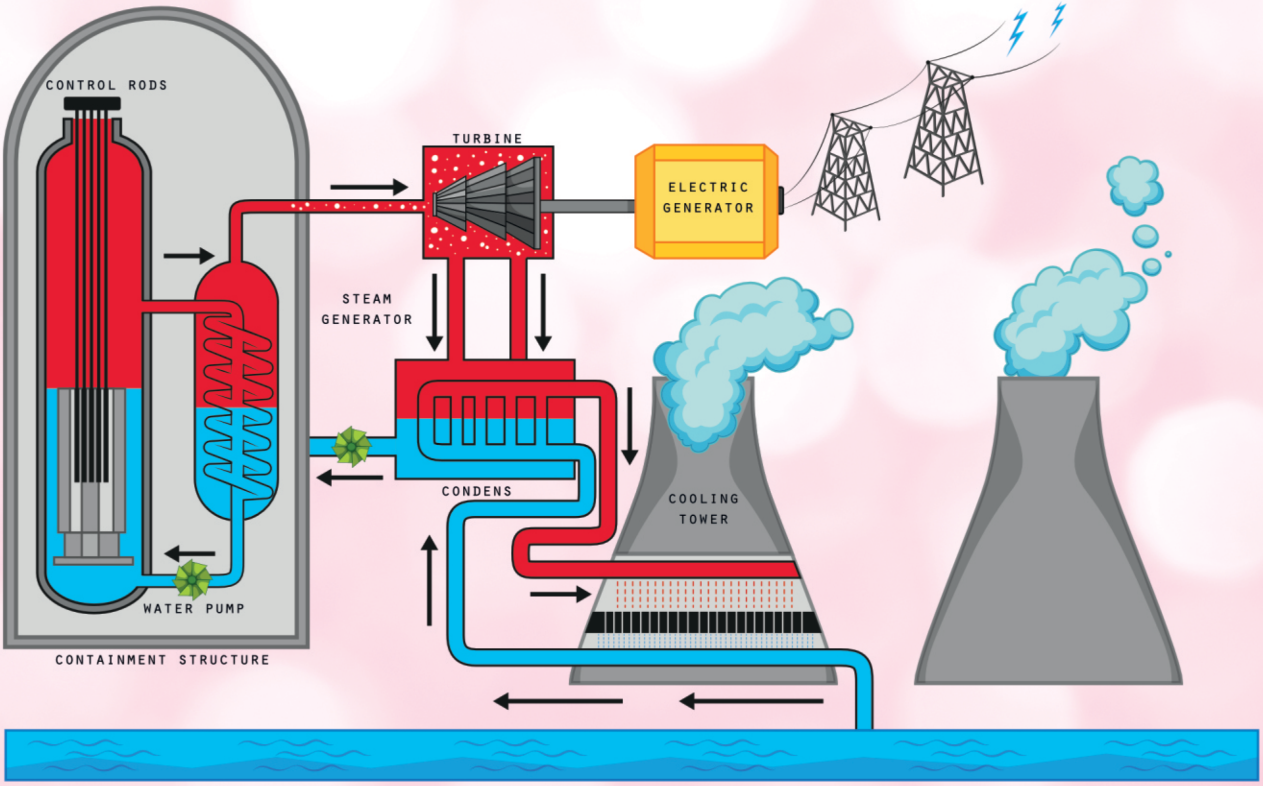

Nuclear Reactor

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CONTENTS

10th Physics

UNIT 10 Simple Harmonic Motion and Waves

Q.1 Define vibratory motion (oscillatory motion). 10110001

Ans. *If a body moves back and forth or to and fro about a fixed point or equilibrium position then this motion is said to be vibratory motion.*

Examples:
- The motion of simple pendulum.
- The motion of mass and spring system.
- The motion of a swing.

Q.2 What is meant by Simple Harmonic Motion? Prove that mass attached with a spring performs Simple Harmonic Motion. **(Board 2015)** 10110002

Ans. Simple Harmonic Motion: **(Board 2018,20,21,22)**

"The kind of vibratory motion in which acceleration of the body is directly proportional to the displacement from the mean position and is always directed towards the mean position is known as Simple Harmonic Motion". $\alpha \propto -x$

OR

"Simple Harmonic Motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position".

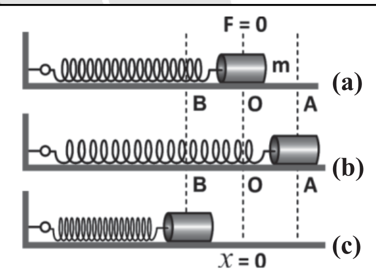
Conditions for SHM:

A body executing Simple Harmonic Motion must fulfill the following conditions.

(i) Acceleration of a body must be directly proportional to the displacement from the mean position.

(ii) Acceleration of body should be directed towards its mean position i.e. $a \propto -x$.

(iii) The system should be frictionless and body executing SHM must have inertia and restoring force.



SHM of a Mass - Spring System

Motion of Mass Attached With a Spring

Consider a body of mass 'm' is attached with a spring and is placed on a horizontal surface. Other end of spring is attached with a firm support. There is no extension in the spring in this state. This means that body is at equilibrium position.

If an external force is applied on the mass, the length of spring increases by an amount 'x' and mass move from 'O' to new position 'A' which is called extreme position.

Hooke's Law:

According to Hooke's Law

"*The external force applied on the spring is directly proportional to the increase in length" i.e.*

$F_{ext} \propto x$

$F_{ext} = kx$ Where "k" is constant and is called spring constant.

Spring Constant: **(Board 2021, 22)**

The ratio of external force acting on a spring to the increase in length is called spring constant. Mathematically it can be written as:

$$k = \frac{F_{ext}}{x}$$

Unit: Its unit is Nm^{-1}.

The value of k is a measure of the stiffness of the spring. Stiff spring have large value of k and soft spring have small value of k.

Restoring Force:

(Board 2021,23)

When an external force is applied on the spring, its length will increase. After releasing the force, the spring will move towards mean position. The motion of spring towards mean position is due to a force which is called restoring force.

OR

Restoring force always pushes or pulls the object performing oscillatory motion towards mean position.

If displacement is 'x' of mass 'm' then restoring force is:

$$F = -kx \qquad \text{.........(i)}$$

Here, negative sign indicates that restoring force of spring is opposite to the direction of motion or displacement of body from mean position.

When mass 'm' is set free, it starts moving towards 'O'.
According to 2nd law of motion.

$$F = ma \qquad \text{..............(ii)}$$

comparing (i) and (ii)

$$ma = -kx$$

$$a = -\frac{k}{m}x$$

$$a = -\text{constant}\,(x)$$

$$a \propto -x$$

This shows that acceleration is directly proportional to displacement from the mean position and negative sign shows that it is directed towards mean position.

When the mass 'm' moves towards the point 'O' its displacement 'x' goes on decreasing. ON reaching the point 'O', 'x' becomes zero and so the acceleration 'a' of the mass 'm' reduces to zero. Due to inertia, the mass 'm' does not stop at the point 'O' but continues its motion towards left till it reaches the other extreme point 'B'. During this motion, the spring is now compressed. Now the restoring force and the acceleration due to it, are opposite to motion of the mass'm'. this means that the acceleration of the mass 'm' is still directed towards the point 'O'. this process continues and the body keeps on vibrating between these points.

Conclusion:

As the acceleration of the body is directly proportional to its displacement from the mean position and is always directed towards the mean position, therefore, we can say that the motion of a mass attached to a spring is Simple Harmonic Motion.

Time Period:

The time period of Simple Harmonic Motion of a mass attached to a spring can be found by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Q.3 Explain the motion of ball in bowl perform Simple Harmonic Motion. 10110003

Ans. Ball and Bowl System: (Board 2016,20,23)

The motion of a ball placed in a bowl is another example of simple harmonic motion.
Consider a ball is placed at the mean position 'O', that is, at the center of the bowl.

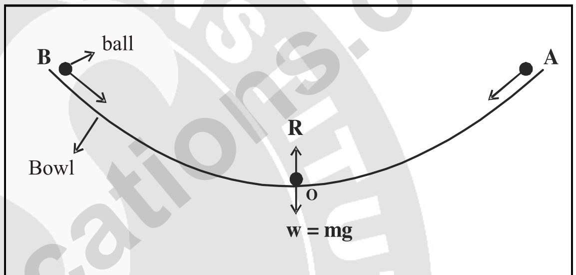
Vertical Forces acting on the ball:

When the ball is at mean position 'O', the force acting on the ball is zero because at this position two vertical forces that is the weight of the ball acting downward is equal to the upward normal force of the surface of the bowl. Hence they cancel out each others effect so there is no motion.

Motion of ball under Restoring Force:

When an external force is applied on the ball and bring the ball to position A and then release it, the ball will start moving towards the mean position 'O' due to the restoring force caused by the weight of the ball.

Speed of ball between position A and B:



(i) When the ball is disturbed from 'O' to 'A' it starts moving towards the mean position 'O' due to the restoring force caused by its weight.

(ii) At mean position 'O' the ball gets maximum speed and due to inertia it moves towards the extreme position B.

(iii) While moving towards the position 'B' the speed of the ball decreases due to the restoring force which acts towards the mean position.

(iv) At position 'B' the ball stops for a while, here the speed of ball become zero and then again ball moves towards the mean position 'O' under the action of Restoring Force.

Acceleration of ball between 'A' and 'B':

(i) The speed of ball increases while moving from point 'A' to 'O' the acceleration of the ball is towards 'O'.

(ii) The acceleration of the ball remains towards mean position 'O', when it moves from point 'O' towards point 'B', because now speed of the ball decreases. It means acceleration of the ball always towards the mean position i.e. towards point 'O'.

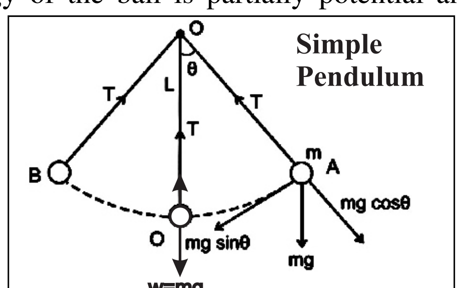
Energy changes between 'A' and 'B':

- At point 'O' the ball is at its lowest position so the potential energy of the ball is minimum and K.E of the ball is maximum.
- At point 'A' or 'B' at the highest level, the P.E is maximum and K.E of the ball is minimum i.e. zero.
- In between extreme and mean position, the energy of the ball is partially potential and partially kinetic. But the total energy remains the same.

Q.4 What is Simple Pendulum? Prove that motion of Simple Pendulum is SHM. (Board 2017) 10110004

Ans. Simple Pendulum:

"*A Simple Pendulum consists of a single isolated bob suspended from frictionless support by light inextensible string.*" A small bob of mass 'm' is suspended by light inextensible string of length 'L'.



Vertical Forces at mean position

When simple pendulum is at the mean position 'O' the net forces acting on the bob is zero and the bob is stationary. The weight of the bob is equal to the tension in the string.

Forces at Extreme Position.

When the bob is at extreme position A, the net force is not zero. There is no force acting along the string as the tension in the string cancels the component of weight mg cosθ. Hence there is no motion along this direction the component of weight, mg sinθ is directed towards mean position and act as a restoring force due to this force bob starts moving towards the mean position.

Velocity of bob between 'A' and 'B':

(i) In equilibrium position, the pendulum is held stationary in a vertical position at point "O".

(ii) When the bob is disturbed from 'O' to 'A' it starts moving towards the mean position under the action of gravitational force.

(iii) At 'O' the velocity of bob is maximum and due to inertia, the bob will not stop at 'O' and move to the other end 'B' and the velocity of the bob begin to decrease, and becomes zero at 'B'.

(iv) The bob starts its motion from 'B' to 'O' and towards 'A' the bob will continue its motion between 'A' and 'B'.

Acceleration of bob between 'A' and 'B':

(i) The speed of bob increases while moving from point 'A' to 'O', the acceleration of the bob is towards 'O' the direction of acceleration remains same.

(ii) The direction of acceleration remain same towards 'O' during motion from point 'O' to 'B' because the speed of bob start decreasing.

This shows that acceleration is always directed towards the mean position and is directly proportional to the displacement. So we can say that motion of simple pendulum is simple harmonic motion.

Energy changes between 'A' and 'B':

(i) At point 'O', the bob is at lowest position so the potential energy of the bob is minimum and K.E of bob is maximum.

(ii) At point 'A' or 'B', at the highest level, the potential energy is maximum and K.E of the bob is minimum i.e. zero.

(iii) In between extreme and mean position, the energy of the bob is partially potential and partially kinetic. But the total energy remains the same.

Note: In simple harmonic motion, a body repeat its to and fro motion in equal interval of time about its mean position.

Time Period: Time period of simple pendulum can be found by the formula:

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

Where 'ℓ' is length of pendulum, which is equal to the distance between the point of suspension and center of bob.

Factors on which Time Period of Simple Pendulum depends:

The time period of simple pendulum depends on length 'ℓ' and the value of gravitational acceleration 'g'. It is independent of mass of body.

Q.5 Explain the following terms: 10110005

(a) Vibration (Board 2014) **(b) Time Period** (Board 2014) **(c) Frequency** (Board 2024)
(d) Amplitude (Board 2014) **(e) Periodic Motion** (Board 2024) **(f) Displacement**

Ans.

(a) Vibration:

One complete round trip of the vibrating body about its mean position is called Vibration.

(b) Time Period (T):

The time required by the vibrating body to complete one vibration is called Time Period.

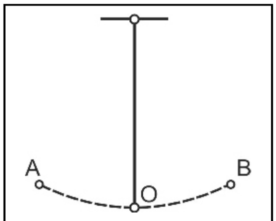
(c) Frequency (f):

The number of vibrations of a vibrating body completed in one second is called Frequency.

Unit: The unit of frequency is Hertz or cycle/sec or vib/sec.

Mathematically, it can be written as:

$f = \frac{1}{T}$, this relation shows that it is the reciprocal of time period.



Mean Position

(d) Amplitude

The maximum displacement between mean position and extreme position of the vibrating body on either side is called Amplitude.

(e) Periodic Motion:

The type of motion which is repeated after regular interval of time is called Periodic Motion.

(f) Displacement:

The distance of vibrating body at any time from the mean position is called Displacement.

Q.6 Write the characteristics of Simple Harmonic Motion. OR
What are the important features of SHM? **(Board 2014,17,19)** **10110006**

Ans. Characteristics of Simple Harmonic Motion:

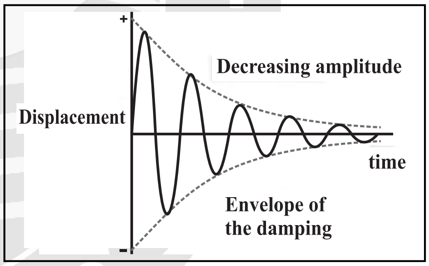
(1) In SHM, body always vibrates about fixed point.

(2) Acceleration is always directed towards the mean position.

(3) Magnitude of acceleration is directly proportional to the displacement from the mean position and a = 0 at the mean position, 'a' is maximum at extreme position.

(4) Velocity is maximum at mean position and minimum at extreme position.

Q.7 What are damped oscillations? How damping progressively reduces the amplitude of oscillation? OR
What do you mean by Damped Oscillation? Explain. **(Board 2016, 22)** **10110007**
OR
How can the strength of oscillations be reduced? Also describe its application.



Ans. Damped Motion: *"The friction reduces the mechanical energy of the system as time passes, the strength of motion reduces so that the motion is said to be damped".*

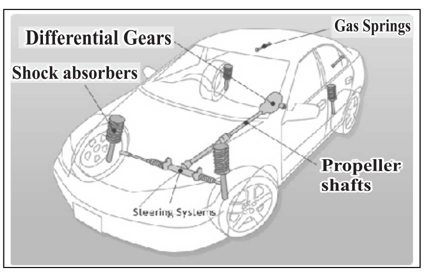
Damping progressively reduces the amplitude of the motion.

Damped Oscillations: **(Board 2020)**

"The oscillations of a system in the presence of some resistive force are called Damped Oscillations."

Explanation: Vibratory motion of ideal system, in the absence of any friction or resistance continues for unlimited time (Indefinitely) under the action of a restoring force. Practically in all systems the force of friction retards (reduces) the motion, so the system do not oscillate for unlimited time.

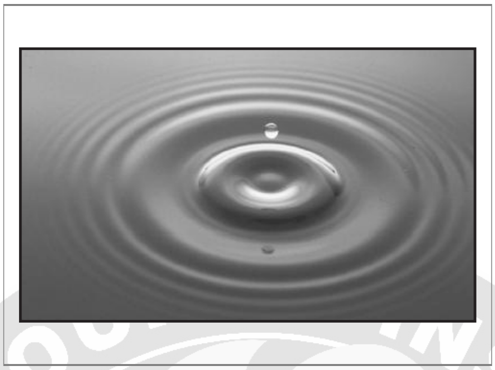
Application: Shock absorbers in automobiles are one practical application of damped motion. A shock absorber consists of a piston moving through a liquid such as oil. The upper part of the shock absorber is firmly attached to the body of the car. When the car travels over a bump on the road, the car may vibrate violently. The shock absorber damp these vibrations and convert their energy into the heat energy of the oil. Thus in the presence of some resistive force the oscillations of the system become damped oscillations.



Q.8 What is wave? Write its importance in our daily life. **(Board 2018,20)** **10110008**

Ans. *"Wave is a mechanism in which energy is transferred from one place to another place due to disturbance in the medium".* OR

"A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time."



Importance:

There are some waves, which we can see while there are some, which we cannot see, but can be detected with some sensitive instruments.

1- Sound reaches in our ears in the form of waves.
2- The sunlight and heat reaches us through waves.
3- The join broadcasting of radio and television is possible by waves.
4- The defects in human body e.g. broken bones, tumors, bullets can also be detected by waves.

Q.9 What is wave motion? Explain. **(Board 2017)** **10110009**

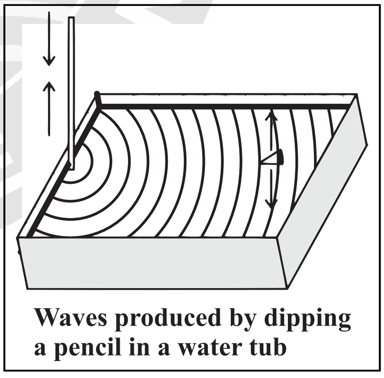
OR

What is wave motion? Demonstrate the production and propagation of waves with vibratory motion of object.

Ans. *"A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time."*

Experiment 1

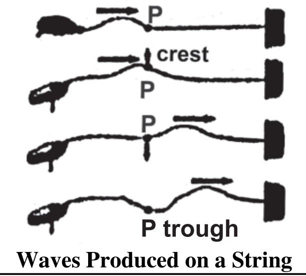
Take a tub of water and dip one end of a pencil at the edge of a tub. Move the pencil rapidly up and down vertically. The ripples emerge outward on the surface of water which moves away from the source. Place some pieces of paper or cork equally spaced in the direction of waves and observe the movement of paper, we will see that every piece of paper move up and down about its mean position. They are not displaced forward from their original position along with water waves. The pieces exhibit vibratory motion and have consecutive vertical vibratory motion. Hence this disturbance is transferred along with the wave and visible water waves are observed.



Waves produced by dipping a pencil in a water tub

Experiment 2

Take a rope and mark a point P on it. Tie one end of the rope with a hook and stretch the string by holding its other end in your hand as shown in fig. Now, flipping the rope up and down regularly will set up a wave in the rope which will travel towards the fixed end. The point P on the rope will start vibrating up and down as the wave passes across it. The motion of point P will be perpendicular to the direction of the motion of wave.



Waves Produced on a String

Conclusion:

From this we can conclude that by moving the free end up and down disturbance is generated and transferred to the other end of the string and they start vibratory motion about their mean position. This disturbance travels along the string in the form of waves.

Q.10 How many categories of waves are there? Give examples of each. 10110010

OR

How can you define the term wave? Elaborate the difference between mechanical and electromagnetic waves? Give examples of each. **(Board 2017)**

Ans. *"A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time."*

There are two categories of waves.

(i) Mechanical Waves **(Board 2019)**

The types of waves which require a medium for their production and propagation are called Mechanical Waves.

Examples:

(i) Waves on the surface of water. (ii) Waves produced in stretched string.
(iii) Sound waves

(ii) Electromagnetic Waves **(Board 2023)**

The waves which do not require a medium for their propagation are called Electromagnetic waves.

Examples:

(i) Radio waves (ii) Heat and light waves
(iii) X-Rays (iv) Television Waves

Q.11 Explain the types of Mechanical Waves. Explain with examples. **(Board 2018,23)** 10110011

Ans. Waves are classified as following, depending upon the direction of displacement of medium with respect to the direction of motion of wave itself.

i) Longitudinal or Compressional Waves:

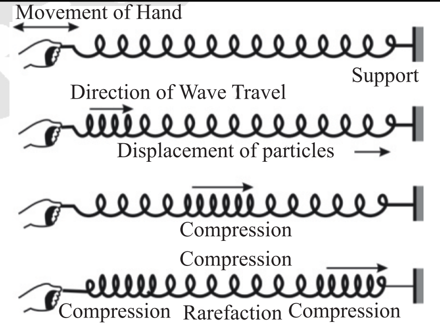
"In longitudinal waves the particles of the medium move back and forth, along the direction of propagation of wave". OR

"The type of mechanical waves in which the direction of vibratory motion of particles of medium is parallel to the direction of propagation of wave". e.g.,

(i) The sound waves
(ii) Waves produced in mass attached with spring.

Example:

Longitudinal waves can be produced on a spring (slinky) placed on a smooth floor or a long bench. If one end of the slinky is fixed with rigid support by holding the other end into the hand and give it a regular push or pull in the direction of its length a series of disturbance (waves) will start moving along the length of the slinky.



Longitudinal waves on a slinky spring

Regions of Longitudinal Waves:

Such waves which consist of two regions called compression and rarefaction.

(a) Compression: **(Board 2019)**

"The regions in which the loops of spring are closed together are called Compressions".

In the regions of compression, particles of medium are closed together.

(b) Rarefactions: (Expansions)

"The regions where the loops are spaced apart are called rarefaction."

In the regions of rarefaction particles of medium are also spaced apart.

ii) Transverse Waves:

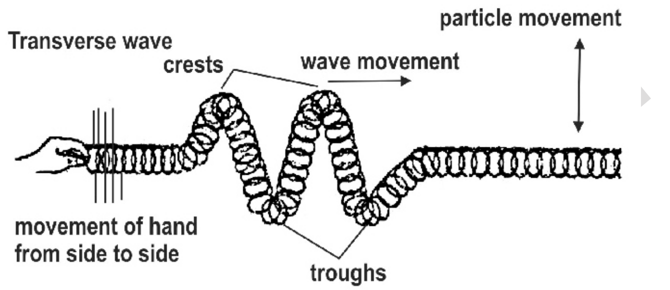
"In transverse waves the motion of particles of medium is perpendicular to the motion of wave". e.g.

i) Waves produced in slinky by up and down motion.

ii) Waves produced on water surface.

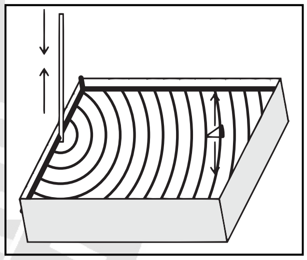
Example 1

We can produce transverse waves with the help of a slinky. Stretch out a slinky along a smooth floor or long bench with one end fixed. Grasp the other end of slinky and move it up and down quickly.



Transverse waves on slinky spring

A wave in the form of alternative crest and trough will start travelling towards the fixed end. The crest is the highest point while the trough is the lowest point of the particles of the medium from the mean position. The crest and trough move perpendicular to the direction of the wave. The waves produced by moving one end of stretched string up and down also produces transverse waves because different parts of the string vibrate perpendicular to the string.



Example 2

If one end of the pencil is dipped in water and then move up and down, waves are produced on the surface of water due to which the particles of the medium vibrate up and down, which means that direction of vibratory motion of water particles is perpendicular to the motion of waves.

Q.12 Define the following terms: **10110012**

(i) Crest (ii) Trough (iii) Wavelength

Ans.

(i) Crest: (Highest Points)

The part of transverse waves where particles of medium are above the normal position are called Crest.

(ii) Trough: (Lower Points)

The part of transverse waves where the particles of medium are below the normal position are called Trough.

(iii) Wavelength (λ):

The distance between two consecutive crest or trough is called Wavelength.

It is represented by (λ).

Note: A crest and a trough are joined to make one complete wave.

Q.13 Write a note on "waves as a carrier of energy". Also describe the factors upon which the amount of energy carried by the wave depends. **(Board 2014)** **10110013**

OR

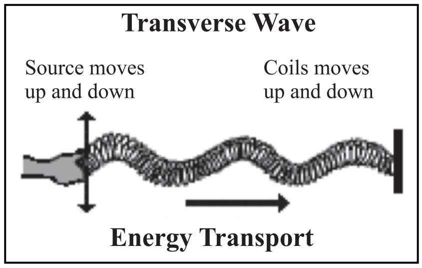
Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment.

Ans. Waves as a Carrier of Energy:

Energy can be transferred from one place to another through waves.

Example 1

When we shake the stretched string up and down we provide our muscular energy to the string. As a result a set of waves can be seen travelling along the string. The vibrating force of hand disturbs the particles of string and sets them in motion. These particles transfer their energy to the adjacent particles in the string. Energy is thus transferred from one place of the medium to the other in the form of waves.

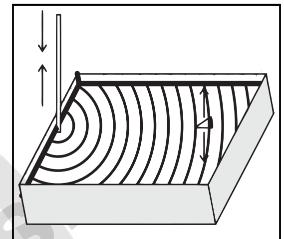


Example 2

Take a rectangular tray and fill it with water. Start moving a vertical rod in the water up and down which produces transverse waves on the surface of water.

Place a cork on the surface of water near the other end of the tray opposite to rod.

When waves pass through cork, the cork vibrates up and down perpendicular to the water surface.



Dependence of Energy Carried by Waves:

The amount of energy carried by the waves depends on the distance of stretched string from its mean position.

The energy of a wave depends on a wave amplitude. If we shake the string faster, we give more energy per second to produce wave of higher frequency, and the wave delivers more energy per second to the particles of string as it moves forward. These activities show that waves transfer energy from one place to another without transferring matter.

Reason:

We have transferred our energy in moving the rod up and down. This energy reaches the cork through water wave due to which cork vibrates.

Conclusion:

(1) Water particles do not make any forward motion along the direction of wave.

(2) They keep on vibrating at their respective places and wave passes through it.

Q.14 What is wave equation? Establish a relation between wave speed (v), frequency (f) and wavelength (λ) or prove that v = f λ. **(Board 2015, 19, 21)** 10110014

OR

Derive a relationship between velocity, frequency and wavelength of a wave. Write a formula relating velocity of a wave to its time period and wavelength. **(Board 2020)**

Ans. Wave Equation:

"The relation between the velocity, frequency and wavelength of the wave is known as Wave Equation."

Derivation:

i) Wave is infact a disturbance in a medium which travels from one place to another and hence have a specific velocity of travelling. This is called the velocity of wave which is defined by

$$Velocity = \frac{displacement}{Time}$$

$$v = \frac{d}{t}$$

ii) If time taken by the wave in moving from one point to another is equal to the time period then the distance covered by the wave will be equal to one wavelength, hence we can write it as

$$v = \frac{\lambda}{T}$$

iii) As the time period 'T' is reciprocal of the frequency 'f' i.e. $T = \frac{1}{f}$

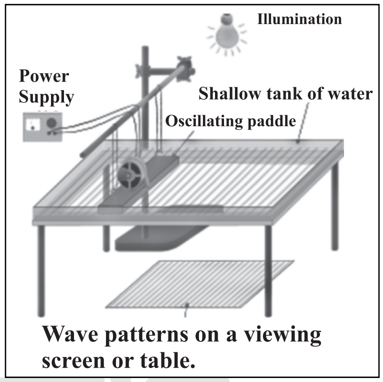
Therefore, $v = \frac{1}{T} \times \lambda$, $v = f\lambda$

iv) This equation is called wave equation and is true for all type of waves i.e. Longitudinal, Transverse etc.

Q.15 Write a note on Ripple Tank. How can we generate straight waves and circular waves with the help of Ripple Tank? **(Board 2019,20)** **10110015**

Ans. Ripple Tank:

It is an apparatus which is used to produce water waves and to study their properties.



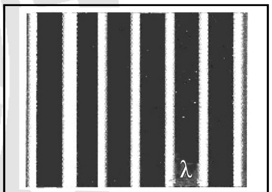
Construction:

It consists of rectangular tray with glass bottom. It is placed nearly half metre above the surface of table by means of four supporting legs. Waves are produced on the surface of water present in the tray by means of vibrator. The vibrator is an oscillating electric motor which is fixed on wooden bar. The plate is suspended by means of rubber band and its lower end just touches the surface of water.

Generation of Straight Waves:

On setting vibrator on, the plates start vibrating and straight waves are generated on water surface.

A lamp is hung over tray, to see image of water waves which is obtained on white paper or screen. The crest of wave appear as bright line on the paper because they function like convex lens and converge the light falling on them. The trough behaves like concave lens and diverge the light and appear as dark straight portions between bright lines.

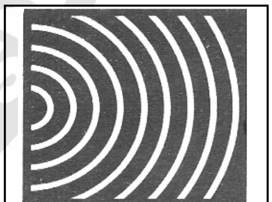


Plane Waves

Generation of Circular waves:

To generate circular waves, the vibrating bar is raised up and a knob is attached, which is lowered in such a way that it touches the surface of water, when vibrator is set, circular waves are produced.

The picture of waves has been taken by the help of a high power camera. The waves were seen continuously moving on the paper.


Circular Waves

Q.16 Describe the following characteristics of waves: **10110016**

(a) Reflection (b) Refraction (c) Diffraction **OR**

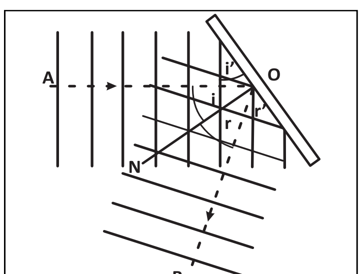
Explain the following properties of waves with reference to ripple tank experiment

(a) Reflection (b) Refraction (c) Diffraction

Ans. To study these properties we will use ripple tank.

(i) Reflection of Waves:

When waves moving in one medium fall on the surface of another medium they bounce back into the first medium such that the angle of incidence is equal to the angle of reflection. The phenomena is called reflection of waves.



Reflection of water waves from a plane barrier

Explanation:

The water waves are reflected according to the laws of reflection of light waves. To observe the reflection of water waves straight waves are generated in the ripple tank. Place a plane surface obstacle in the path of waves making certain angle with the direction of propagation of waves. After striking the obstacle, the waves will be reflected in a particular direction to obey the laws of reflection.

Angle of Incidence:

The angle between incident ray and normal is called angle of incidence '∠i'.

Angle of Reflection:

The angle between reflected ray and normal is called angle of reflection '∠r '.

Angle of Incidence and angle of Reflection:

The angle between the line AO and normal NO is called angle of Incidence and the angle between OB and ON is the angle of Reflection.

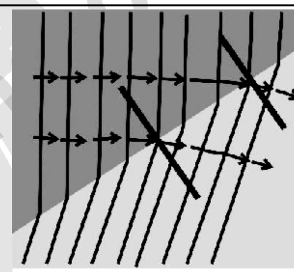
It is evident that angle of incidence is equal to angle of reflection i.e.

$$\angle i = \angle r.$$

(ii) Refraction: **(Board 2024)**

"When waves from one medium enter into the second medium at some angle their direction of travel may change. This phenomenon is called refraction of waves."

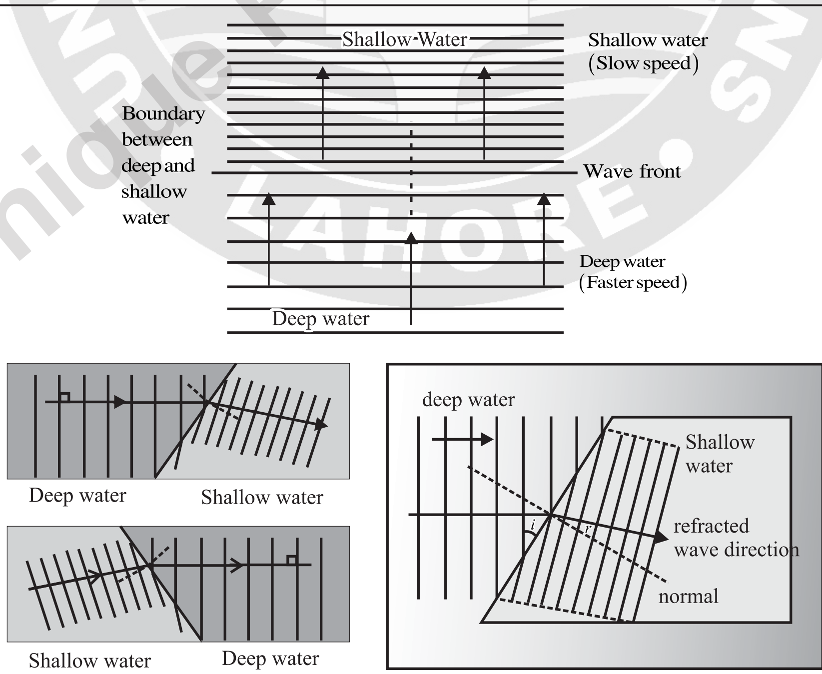
Explanation:


Refraction of Water

The speed of light is more in air or vacuum than in glass or water. The speed of water waves depend upon the depth of water. Its speed is reduced when it enters into the shallow water. To observe the relation between wave speed with water depth cover the half of the bottom of the ripple tank with a thick glass plate. By doing so we get two portions of water with different depths. The edge of the plate separating the two portions should be parallel to the bar of the vibrator.

When the electric motor is switched on, straight waves are produced on the surface of water. We find that the wavelength of the wave decreases when they reach the shallow part. The frequency of the wave does not change in both parts of the water because it is equal to the frequency of vibrator.

In the shallow part, the decrease in wavelength is due to decrease in speed of wave according to the equation $v = f\lambda$.



Refraction of Water Waves

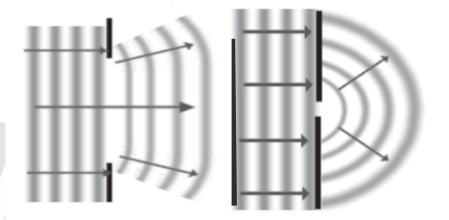
For the observation of refraction of water waves, we repeat the above experiment such that the boundary between the deep and the shallower water is at some angle to the wave front. Now we will observe that in addition to the change in wavelength, the waves change their direction of propagation as well. Note that the direction of propagation is always normal to the wave fronts. This change of path of water waves while passing from a region of deep water to shallower one is called refraction.

(3) Diffraction: **(Board 2022)**

The bending or spreading of waves around the sharp edge or corners of obstacles is called Diffraction.

Explanation:

To generate straight waves in a ripple tank, place two obstacles in a line in such a way that the separation between them is equal to the wavelength of water wave. After passing through the slit between two obstacles the wave can be seen spreading in every direction and changing to almost semicircular pattern.



Diffraction of waves through a large slit **Diffraction of water wave through a small slit**

Condition:

Diffraction of wave can be observed clearly only when size of slit or obstacle is nearly equal to the wavelength of the wave.

But if the size of the slit is larger than the wavelength of the wave, then diffraction is not significant and waves keep their initial motion even after passing through the slit, and their shape remains straight. A little diffraction effect appears near the corners of the obstacle.

Q17. What are wave fronts? **10110017**

Ans. Wave fronts:

A surface on the wave, where all points of waves have same phase of oscillation. Wave fronts generally form a continuous line or surface.

There are three types of wave fronts:

(i) Spherical wave front.
(ii) Plane wave front.
(iii) Cylindrical wave front.

Q18. Does increasing the frequency of a wave also increase case of its wavelength? If not, how are these quantities related? 10110018

Ans. As we know that $v = f\lambda \qquad \Rightarrow f = \frac{v}{\lambda}$

According to this relation if wave speed is constant then wavelength 'λ' will decrease as the frequency increases. The frequency and wavelength of a wave have inverse relation with each other.

Multiple Choice Questions

Choose the correct answer from the following choices:

Exercise MCQs

1. Which of the following is an example of simple harmonic motion? 10110018
(a) Motion of a simple pendulum
(b) The motion of ceiling fan
(c) The spinning of the Earth on its axis
(d) A bouncing ball on a floor

2. If the mass of the bob of a pendulum is increased by a factor of 3, the period of the pendulum's motion will: (Board 2016,19) 10110019
(a) be increased by a factor of 2
(b) remains the same
(c) be decreased by a factor of 2
(d) be decreased by a factor of 4

3. Which of the following devices can be used to produce both a transverse and longitudinal waves? (Board 2015) 10110020
(a) a string
(b) a ripple tank
(c) a helical spring (slinky)
(d) a tuning fork

4. Waves transfer: (Board 2014,15,21) 10110021
(a) energy (b) frequency
(c) wavelength (d) velocity

5. Which of the following is a method of energy transfer? (Board 2015) 10110022
(a) conduction (b) radiation
(c) wave motion (d) all of these

6. In a vacuum all electromagnetic waves have the same: (Board 2018,20) 10110023
(a) speed (b) frequency
(c) amplitude (d) wavelength

7. A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves at a distance of 50 cm. The velocity of the wave is: (Board 2014) 10110024
(a) 53 cms^{-1} (b) 60 cms^{-1}
(c) 750 cms^{-1} (d) 1500 cms^{-1}

8. Which of the following characteristics of a wave is independent of the others? (Board 2014,17,22) 10110025
(a) speed (b) frequency
(c) amplitude (d) wavelength

9. The relation between v, f and λ of a wave is: (Board 2014 & 2015,18) 10110026
(a) $v f = \lambda$ (b) $f \lambda = v$
(c) $v \lambda = f$ (d) $v = \lambda / f$

Additional MCQs

10. The disturbance travelling in a medium is called: 10110027
(a) Wave motion
(b) Simple Harmonic Motion
(c) Motion
(d) Both a, and b

11. The waves, which are used to detect the broken bones are called: 10110028
(a) Light waves (b) X-rays
(c) Sound waves (d) Both b and c

12. The force applied on the mass attached with a spring is represented by: 10110029
(a) F_a (b) F_c
(c) F_{ext} (d) F_s

13. If there is no extension in the spring then this position is called: 10110030
(a) Equilibrium position
(b) Non-equilibrium
(c) Neutral equilibrium
(d) Stable equilibrium

14. The unit of spring constant is: 10110031
(a) m (b) kg
(c) Nm^2 (d) Nm^{-1}

15. If the displacement in spring is 'x' of mass "m" attached with a spring then restoring force is: 10110032
(a) F = ma (b) F = kx
(c) F = - kx (d) $F = \frac{m}{a}$

16. The ratio of external force applied on the spring to displacement is called:
(a) Hooke's Law 10110033
(b) Constant
(c) Spring constant
(d) Force

17. The time required to complete one round trip (vibration) about mean position is called: 10110034
(a) Time period (b) Frequency
(c) Amplitude (d) Vibration

18. The time period of mass attached with a spring can be calculated by: (Board 2015) 10110035

(a) $T = 2\pi\sqrt{\ell / g}$

(b) $T = 2\pi\sqrt{\frac{k}{m}}$

(c) $T = 2\pi\sqrt{g / \ell}$

(d) $T = 2\pi\sqrt{\frac{m}{k}}$

19. The formula for the time period of a simple pendulum: (Board 2014,15,19) 10110036

(a) $T = 2\pi\sqrt{\ell / g}$

(b) $T = 2\pi\sqrt{\frac{m}{k}}$

(c) $T = 2\pi\sqrt{g / \ell}$

(d) $T = 2\pi\sqrt{\frac{k}{m}}$

20. The maximum displacement from mean position is called: 10110037

(a) Maximum height
(b) Time period
(c) Amplitude
(d) Interval

21. The displacement produced in the spring is directly proportional to force is called: 10110038

(a) Hooke's law
(b) Boyle's law
(c) Newton's law
(d) Joule's law

22. At mean position of pendulum, the potential energy of the pendulum is: 10110039

(a) Maximum
(c) Much more
(b) Minimum
(d) Both a and c

23. At mean position kinetic energy of the ball is: 10110040

(a) Minimum (b) Zero
(c) Maximum (d) 10 J

24. At extreme position potential energy of the pendulum is: 10110041

(a) Maximum (b) Minimum
(c) Both a and b (d) Zero

25. In Simple Harmonic Motion, the acceleration of the body is_____ proportional to the displacement. 10110042

(a) Inversely (b) Directly
(c) Equally (d) Ratio

26. The value of acceleration in Simple Harmonic Motion at mean position is: 10110043

(a) Maximum (b) Zero
(c) 10 N (d) Both a and b

27. The waves in which particles of the medium vibrate parallel to the direction of waves are called: 10110044

(a) Longitudinal waves
(b) Transverse waves
(c) Electromagnetic waves
(d) Both b and c

28. The waves in which particles of the medium vibrate perpendicular to the direction of waves are: 10110045

(a) Electromagnetic waves
(b) Sound waves
(c) Both 'a' and 'b'
(d) Transverse waves

29. The sound waves are the example of: 10110046

(a) Longitudinal waves
(b) Transverse waves
(c) Electromagnetic waves
(d) X-rays

30. The energy is transferred from one place to another : 10110047

(a) through matter
(b) through waves
(c) Both a and b
(d) through vacuum

31. The waves have properties: 10110048

(a) Reflection (b) Refraction
(c) Diffraction (d) All of these

32. The time period of body attached to spring depend on: 10110049

(a) mass
(b) gravitational constant
(c) length
(d) amplitude

33. The part of waves at which particles of the medium are below the normal position are called: 10110050

(a) Extreme position
(b) Crest
(c) Trough
(d) Compression

34. The distance between two consecutive trough or crest is called: 10110051
(a) Wavelength (b) Frequency
(c) Time period (d) Amplitude

35. The number of waves passing through a point in one second is called:
(a) Time period (b) Cycle 10110052
(c) Frequency (d) Amplitude

36. The unit of frequency is: 10110053
(a) Hertz
(b) Vibration per second
(c) Cycle per second
(d) all of above

37. The speed of waves can be calculated by: 10110054
(a) vt (b) $d \times t$
(c) $f\lambda$ (d) Tf

38. The water waves after striking the hurdle will: 10110055
(a) Reflect (b) Refract
(c) Diffract (d) All of above

39. When water waves enter the region of shallow water, which quantity will change. **(Board 2020)** 10110056
(a) Frequency
(b) Time period
(c) Amplitude
(d) Wavelength

40. The oscillations of a system in the presence of which force are called damp oscillations: 10110057
(a) Resistive force
(b) Attractive force
(c) Coulomb force
(d) Both a and b

41. The example of shock absorber of the vehicles are: **(Board 2014)** 10110058
(a) Simple harmonic motion
(b) Vibratory motion
(c) Damped motion
(d) Linear motion

42. Time period is reciprocal of 10110059
(a) Frequency (b) Cycle
(c) Wave-length (d) Amplitude

43. The water waves obey the laws of 10110060
(a) Reflection (b) Refraction
(c) Diffraction (d) All of these

44. The product of frequency and time period is equal to: 10110061
(a) v (b) 1
(c) 0 (d) λ

45. If the mass of bob of a simple pendulum is doubled, its time period:
(a) is doubled 10110062
(b) becomes four times
(c) remains same
(d) becomes half

46. If the length of a simple pendulum is halved, its time period 'T' will become: **(Board 2022)** 10110063
(a) $\frac{T}{2}$ (b) $\frac{T}{\sqrt{2}}$
(c) $\sqrt{2}\,T$ (d) 2T

47. Diffraction of wave can be observed clearly only when the size of slit or obstacle is nearly ___________ to the wavelength of the wave: 10110064
(a) Two times (b) Equal
(c) Four times (d) Half

48. In simple pendulum motion, restoring force is provided by: **(Board 2014)** 10110065
(a) Air resistance
(b) Tension in the string
(c) Inertia
(d) Weight of the body

49. Ripple tank is an instrument which is used to study the characteristics of:
(a) Mechanical Waves 10111066
(b) Light Waves
(c) Radio Waves
(d) Electro-Magnetic Waves

50. Radio waves are: 10111067
a) Longitudinal waves
b) Transverse waves
c) Electromagnetic waves
d) Mechanical waves

51. The product of frequency and wavelength is equal to:
(Board 2015) 10110068
(a) time period (b) amplitude
(c) wave speed (d) wave energy

52. When a body moves to and fro about a point, its motion is called: **(Board 2015) 10110069**
(a) random motion
(b) vibratory motion
(c) linear motion
(d) rotatory motion

53. If time period is given the frequency is calculated as: **(Board 2015) 10110070**
(a) $f = \frac{1}{T}$ (b) $f = \frac{2}{T}$
(c) $f = \frac{3}{T}$ (d) $f = \frac{4}{T}$

54. The distance between two consecutive waves compressions or rarefactions is called: **(Board 2015) 10110071**
(a) focal length (b) wave length
(c) frequency (d) time period

55. The spring constant is:
(Board 2016) 10110072
(a) $k = \frac{-F}{x}$ (b) $F = ma$
(c) $w = mg$ (d) $k = \frac{-x}{m}$

56. Frequency is equal to:
(Board 2016) 10110073
(a) $f = \frac{1}{T}$ (b) $f = \frac{l}{g}$
(c) $f = 2\pi\sqrt{\frac{l}{g}}$ (d) $f = kx$

Answer Key

1.	a	**2.**	b	**3.**	c	**4.**	a	**5.**	d	**6.**	a	**7.**	b
8.	c	**9.**	b	**10.**	a	**11.**	b	**12.**	c	**13.**	a	**14.**	d
15.	c	**16.**	c	**17.**	a	**18.**	d	**19.**	a	**20.**	c	**21.**	a
22.	b	**23.**	c	**24.**	a	**25.**	b	**26.**	b	**27.**	a	**28.**	d
29.	a	**30.**	c	**31.**	d	**32.**	a	**33.**	c	**34.**	a	**35.**	c
36.	d	**37.**	c	**38.**	a	**39.**	d	**40.**	a	**41.**	c	**42.**	a
43.	d	**44.**	b	**45.**	c	**46.**	b	**47.**	b	**48.**	d	**49.**	a
50.	c	**51.**	c	**52.**	b	**53.**	a	**54.**	b	**55.**	a	**56.**	a

Review Questions

Q.10.1 What is simple harmonic motion? What are the necessary conditions for a body to execute simple harmonic motion? OR Define simple harmonic motion. Write down its three properties.
(Board 2014,15,23) 10110074

Ans. The acceleration of the body executing S.H.M is directly proportional to the displacement from the mean position and always directed towards the mean position.
(i) A body always vibrate about its mean position.
(ii) Acceleration is always directed towards mean position.
(iii) Acceleration is directly proportional to the displacement and a = 0 at mean position and 'a' is maximum at extreme position.
(iv) The velocity 'v' is maximum at mean position and zero at extreme position.

Q.10.2 Think of several examples in everyday life of motion that are simple harmonic? **(Board 2024) 10110075**

Ans.
(i) Up and down motion of a leaf in water pond.
(ii) Motion of plucked string fixed at the both ends.
(iii) Motion of swing
(iv) Motion of vibrating prongs of tuning fork

Q.10.3 What are damped oscillations. How damping progressively reduces the amptitude of oscillation? **10110076**

Ans. See Q#7 on Page # 5

Q.10.4 How can you define the term wave? Elaborate the difference between mechanical and electromagnetic waves? 10110077

Ans. Wave: A wave is a mechanism in which energy is transferred from one place to another due to disturbance in the medium.

Mechanical waves	Electromagnetic waves
The type of waves which require a medium for their production and propagation are called mechanical waves. e.g. sound waves.	The type of waves which do not require a medium for their propagation are called electromagnetic **waves**. e.g. light waves.

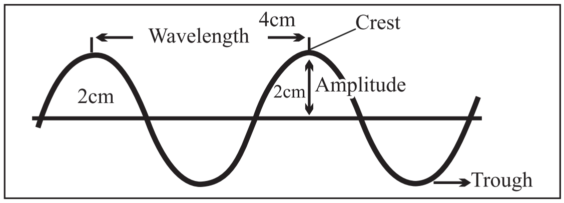
Q.10.5 Distinguish between longitudinal and transverse waves with suitable examples.

Ans. **(Board 2014 & 2015,17) 10110078**

Longitudinal Waves	Transverse Waves
1. In longitudinal waves the particles of the medium move back and forth, along the direction of propagation of wave.	1. In transverse waves the particles of the medium is perpendicular to the motion of wave.
2. Longitudinal waves propagate in the form compression and rarefactions	2. Transverse waves propagate in the form of crests and troughs.
3. Example: Sound waves, waves produced in mass attached with spring	3. Example: Water waves, waves produced in slinky by up and down motion.

Q.10.6 Draw a Transverse wave with an amplitude of 2 cm and a wavelength 4 cm. Label a crest and trough on the wave. 10110079

Ans.



Q.10.7 Derive the relationship between velocity, frequency and wavelength of a wave. Write a formula relating velocity of wave to its time period and wavelength.

Ans. See Q #14 on Page #9 **10110080**

Q.10.8 Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of simple experiment. **10110081**

Ans. See Q #13 on page #9

Q.10.9 Explain the following properties of waves with reference to ripple tank experiment **10110082**

(a) Reflection (b) Refraction (c)Diffraction

Ans. See Q#16 on page # 10,11

Q.10.10 Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related? **10110083**

Ans. See Q#18 on page # 12

Conceptual Questions

Q10.1 If the length of simple pendulum is doubled. What will be change in time period? **(Board 2015) 10110084**

Ans. If the length of simple pendulum is doubled its time period will be $\sqrt{2}\,T$.

As we know

Time period of simple pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

When $\ell' = 2\ell$

Then

$$T' = 2\pi\sqrt{\frac{2\ell}{g}}$$

$$T' = \sqrt{2}\left(2\pi\sqrt{\frac{\ell}{g}}\right)$$

$$T' = \sqrt{2}\,T$$

Q10.2 A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion of the ball simple harmonic? Explain. **10110085**

Ans. In simple harmonic motion, a body moves under the influence of restoring force and a ball dropped from the height moves under the force of gravity.

No, the motion of the ball is not executing SHM. Bouncing ball moves with linear motion while SHM is the vibratory motion. During the bouncing of ball mean position is not specified and it does not fulfill the conditions of simple harmonic motion.

Q10.3 A student performed two experiments with a simple pendulum. He / She used two bobs of different masses by keeping other parameters constant. To his/her astonishment the time period of the pendulum did not change! Why? **10110086**

Ans. Time period of the simple pendulum is independent of mass. Time period of the simple pendulum does not change, with the change of mass, because it does not depend upon mass of the body as

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

Time period of simple pendulum only depend on the length of simple pendulum.

Q10.4 What types of waves do not require any material medium for their propagation? **10110087**

Ans. Electromagnetic waves do not require any material medium to propagate.

Q10.5 Plane waves in the ripple tank undergo refraction when they move from deep to shallow water. What change occurs in the speed of the waves? **10110088**

Ans. The water waves enter into the region of shallow water, their wavelength decreases as given by the formula: $v = f\lambda$

As wavelength decreases, the speed of wave also decreases.

Additional Short Questions

Q.1 Define Vibratory motion. Give conditions of vibratory motion. **10110089**

Ans. To and fro motion of a body around its mean position in equal interval of time is called Vibratory motion, and the particle of the medium does not change their place.

These are some conditions of vibratory motion.

i. The motion is under the action of some restoring force.

ii. Vibratory motion repeats itself after regular intervals of time.

iii. It satisfies law of conservation of energy.

iv. To and fro motion of a body about its mean position.

Q.2 What is meant by Time Period? **(Board 2018)** **10110090**

Ans. Time required to complete one round trip (vibration) is called Time Period.

Q.3 What are Mechanical waves?

OR

Define mechanical waves and give an example. **10110091**

Ans. The waves which require some medium for their propagation are called Mechanical waves. For example sound waves, water waves, string waves.

Q.4 Define Transverse waves. **(Board 2014, 16) 10110092**

Ans. The waves in which particle of the medium vibrate perpendicular to the direction of propagation of waves. For example water waves.

Q.5 Define crest and trough of a wave. **10110093**

Ans. **Crest:** The point at which particles of the medium are above the normal position.

Trough: The point at which particles of the medium are below the normal position.

Q.6 What is frequency? Write its unit. **10110094**

Ans. The number of waves passing through a point in one second is called frequency. Its unit is cycle per sec, Hertz (Hz) or vib/sec.

Q.7 State Hooke's Law. **(Board 2015) 10110095**

Ans. The force applied on the spring is directly proportional to the increase in length is called Hooke's law i.e. $F_{ext} \alpha x$.

Q.8 What is meant by Amplitude? **(Board 2017)** **10110096**

Ans. The maximum displacement from mean position to extreme position during vibratory motion is called Amplitude.

Q.9 Define Compressional waves. / Longitudinal Waves. **(Board 2014)** 10110097

Ans. The waves in which particles of the medium vibrate parallel to direction of propagation of waves are called compressional waves.

Q.10 Define the following terms Reflection, Refraction and Diffraction.

Ans. Reflection 10110098

The bouncing back of water waves after striking the hurdle is called reflection of waves, and it also obeys the laws of reflection of light.

Refraction: **(Board 2019)**

When a ray of light enters from one transparent medium to another transparent medium, it bends away from its path the bending of waves from their incident path is called refraction.

Diffraction **(Board 2018,22)**

The bending of waves around the corner of hurdles is called Diffraction.

Q.11 Give an example, which explain that energy is transferred through waves. 10110199

Ans. Example of such waves is sound waves i.e. sound energy is transferred from one medium to another medium in the form of waves.

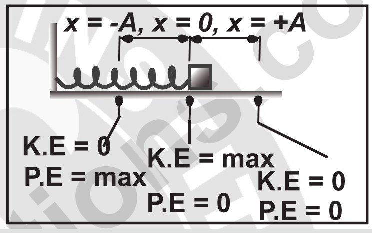
Q.12 Define damped oscillations. 10110100

" **(Board 2023)**

Ans. The oscillations of a system in the presence of some resistive force are damped oscillations".

Q.13 (a) With the help of diagram show the KE and PE values at different position in mass spring system? **(Board 2022)** 10110100 (a)

Ans.



Side Information

Q.13 (b) How does a spider detect its prey? 10110101

Ans. A spider detects its prey due to the vibrations produced in the web.

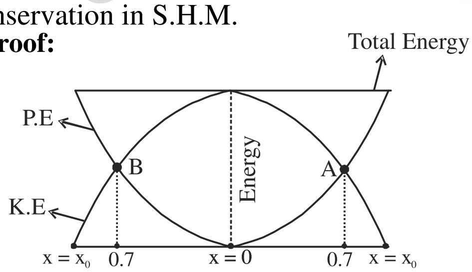
Q.14 Under which restoring force a ball oscillates in a bowl when displaced from the centre of bowl? 10110102

Ans. When a ball is gently displaced from the centre of a bowl, it starts oscillating about the centre due to the force of gravity which acts as a restoring force.

Q.15 What will be the displacement of an object in SHM when the kinetic and potential energies are equal? 10110103

Ans. Following graph shows energy conservation in S.H.M.

Proof:



Instantaneous Kinetic Energy = $\frac{1}{2}Kx_0^2 - \frac{1}{2}Kx^2$

Instantaneous Potential Energy = $\frac{1}{2}Kx^2$

According to the statement

Inst. Potential Energy = Inst. Kinetic Energy

$$\frac{1}{2}Kx^2 = \frac{1}{2}Kx_0^2 - \frac{1}{2}Kx^2$$

$$\frac{1}{2}Kx^2 + \frac{1}{2}Kx^2 = \frac{1}{2}Kx_0^2$$

$$Kx^2 = \frac{1}{2}Kx_0^2$$

$$x^2 = \frac{1}{2}x_0^2$$

By taking square root on both sides

$$\sqrt{x^2} = \frac{\sqrt{x_0^2}}{\sqrt{2}}$$

$$x = \frac{x_0}{\sqrt{2}}$$

$$x = 0.7 \times x_0 \qquad \left(\because \frac{1}{\sqrt{2}} = 0.7\right)$$

As, 0.7 = 70%

At intersecting points A and B, both the kinetic and potential energies are equal. The instantaneous displacement at A and B is 0.7 which is 70% of amplitude.

Hence, we can say that when the Potential and Kinetic energies in SHM are equal then the instantaneous displacement of an oscillator will be 70% of the amplitude.

Q.16 Tell whether or not below mentioned motions are SHM. 10110104

Ans.

(a) Up and down motion of a leaf in water pond. (SHM)

(b) Motion of a ceiling fan. (Not SHM)

(c) Motion of hands of clock. (Not SHM)

(d) Motion of plucked string fixed at the both ends. (SHM)

e) Movement of honey bee. (Not SHM)

Q.17 Who invented the pendulum clock and when? 10110105

Ans. Christian Huygens invented the pendulum clock in 1656. Huygens developed the first clock that could accurately measure time.

Q.18 Relate the speed of longitudinal and transverse waves through solid, liquid or gas. 10110106

Ans. Longitudinal waves move faster through solids than through gases or liquids. Transverse waves move through solids at a speed less than half of the speed of longitudinal waves. It is because the restoring force exerted during up and down motion of the particles of medium is less than the restoring force exerted by a back and forth motion of the particles of the medium in case of longitudinal waves.

Q.19 How much energy is required to generate the high frequency wave as compared to the low frequency wave? 10110107

Ans. To generate a high frequency wave requires more energy per second than to generate a low frequency waves. Thus, a high frequency wave carries more energy than low frequency wave of the same amplitude.

Q.20 What are Seismic Waves? Explain. 10110108

Ans. Earthquake produces waves through the body of the Earth in the form of seismic waves. By studying such waves, the geophysicists learn about the internal structure of the Earth and information about the occurrence of future Earth activity.

Q.21 What happens to the angle of refraction when water waves pass from deep to shallow part of the water? 10110109

Ans. While entering from the part of greater depth to shallower depth wave changes its direction in addition to decrease in wavelength. It is clear that when water enters the shallow part, water waves bend towards the normal on line separating the two parts. Hence, the angle of refraction becomes less than the angle of incidence.

Q.22 Does the magnitude of angle of incidence and angle of refraction equal? 10110110

Ans. As the wave bend towards or away from the normal on refracting hence angle of refraction becomes less than angle of incidence.

Q.23. How many times does the human ear drum can oscillate in one second? 10110111

Ans. Human eardrum can oscillate back and forth up to 20,000 times in one second.

Q.24. Do mechanical waves pass through vacuum, that is, empty space? 10110112

Ans. No, mechanical waves cannot pass through vacuum because they require a material medium for the propagation.

Q.25. What do the dark and bright fringes on the screen of the ripple tank represent? 10110113

Ans. Bright fringes represent crests whereas dark fringes represent troughs of the waves on the screen of the ripple tank.

Because the Crest of wave behaves like a convex lens and converge the rays of light on screen. While trough behaves like a concave lens that diverge rays of light and dark fringe is appeared on the screen.

Solved Examples

10.1 Find the time period and frequency of a simple pendulum 1.0m long at a location where g = 10.0 ms^{-2}. 10110114

Given Data:

Length of pendulum = ℓ = 1.0m

Acceleration due to gravity = g = 10.0 ms^{-2}

To Find:

Time period = T = ?

Frequency = f = ?

Calculation:

As we know that

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$
$$= 2\times 3.14\sqrt{\frac{1.0}{10.0}}$$
$$= 2\times 3.14\times 0.31$$
$$\boxed{T = 1.99\,sec.}$$

Frequency of pendulum is given by

$$f = \frac{1}{T}$$
$$f = \frac{1}{1.99} = 0.50\text{Hz}$$
$$\boxed{f = 0.50\text{Hz}}$$

Result: Time period of simple pendulum is 1.99 sec and frequency is 0.50Hz

10.2 A wave moves on a slinky with frequency of 4Hz and wavelength of 0.4m. What is the speed of the wave? **10110115**

Given data:

Frequency = f = 4 Hz

Wavelength = λ = 0.4m

To Find:

Speed of wave = v = ?

Calculation:

We know that

$$v = f\lambda$$
$$= 4\times 0.4$$
$$\boxed{v = 1.6ms^{-1}}$$

Result:

Hence, the speed of wave is $1.6ms^{-1}$.

10.3 A student performs an experiment with waves in water. The student measures the wavelength of wave to be 10cm. By using stopwatch and observing the oscillations of a floating ball. The student measures the frequency of 2 Hz. If the student starts a wave in one part of a tank of water, how long will it take the wave to reach the opposite side of the tank 2m away?

Given data: **10110116**

Frequency = f = 2Hz

Wavelength = λ = 10cm = 0.1m

Distance = d = 2m

To Find:

Speed = v = ?

Time taken = t = ?

Calculation:

According to the wave equation

$$v = f\lambda$$
$$= (2)\times(0.1)$$
$$\boxed{v = 0.2ms^{-1}}$$

As we know that

$$d = v\times t$$
$$\frac{d}{v} = t$$
$$\frac{2}{0.2} = t$$
$$10s = t$$

Hence

$$\boxed{t = 10\,sec}$$

Result:

The wave with speed $0.2ms^{-1}$ will reach the opposite side of the tank in 10s.

Numerical Problems

10.1 The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on the moon if $g_m = \frac{g_e}{6}$? (Where $g_e = 10ms^{-2}$.) **(Board 2014 & 15)**

10110117

Given Data:

The given data is:

Time period	=	T	= 2s
Length on earth	=	ℓ_e	= ?
Length on moon	=	ℓ_m	= ?

$g_e = 10ms^{-2}$

$g_m = \frac{g_e}{6} = \frac{10}{6} = 1.67\ ms^{-2}$

Formula:

$$T = 2\pi\sqrt{\frac{\ell_e}{g_e}}$$

Calculation:

$$T^2 = 4\pi^2 \frac{\ell_e}{g_e}$$

$$\frac{T^2 g_e}{4\pi^2} = \ell_e$$

Putting values, we get

$$\frac{(2)^2 \times 10}{4 \times (3.14)^2} = \ell_e$$

$$\frac{\not{4} \times 10}{\not{4} \times (3.14)^2} = \ell_e$$

$$\frac{10}{(3.14)^2} = \ell_e$$

$$1.02m = \ell_e \Rightarrow \ell_e = 1.02m$$

Similarly, for moon, we use formula.

$$\ell_m = \frac{T^2 g_m}{4\pi^2}$$

$$= \frac{(2)^2 \times 1.67}{4 \times (3.14)^2}$$

$$= \frac{\not{4} \times 1.67}{\not{4} \times (3.14)^2}$$

$$\ell_m = \boxed{0.17\ m}$$

Result:
The length of simple pendulum on earth will be 1.02m and on moon will be 0.17m.

10.2 A pendulum of length of 0.99m is taken to the moon by an astronaut. The time period of the pendulum is 4.9s. What is the value of 'g' on the surface of the moon? **(Board 2022,23) 10110118**

Given Data:

Length of Pendulum $= \ell = 0.99m$

Time period of Pendulum on Moon $= T_m = 4.9$ sec.

To Find:

Acceleration due to gravity $= g_m = ?$

Calculation:

As we know that

$$T_m = 2\pi\sqrt{\frac{\ell}{g_m}}$$

Taking square on both sides

$$(T_m)^2 = \left(2\pi\sqrt{\frac{\ell}{g_m}}\right)^2$$

$$T_m^2 = 4\pi^2 \frac{\ell}{g_m}$$

Hence

$$g_m = \frac{4\pi^2 \times \ell}{T_m^2}$$

$$= \frac{4 \times (3.14)^2 \times 0.99}{(4.9)^2}$$

$$= \frac{4 \times 9.86 \times 0.99}{24.01}$$

$$= \frac{39.04}{24.01} = 1.63ms^{-2}$$

$$\boxed{g_m = 1.63ms^{-2}}$$

Result:
The value of 'g' on the surface of the moon will be $1.63ms^{-2}$.

10.3 Find the time periods of a simple pendulum of 1 meter length, placed on Earth and on moon. The value of g on the surface of moon is $1/6^{th}$ of its value on Earth. Where g_e is $10ms^{-2}$. **10110119**

Given data:

Length of simple pendulum $= \ell = 1m$

Acceleration due to gravity $= g_e = 10ms^{-2}$ on the surface of Earth

Acceleration due to gravity on the surface of Moon $= g_m = \frac{10}{6}$

$$= \frac{10}{6} ms^{-2} \Rightarrow 1.66ms^{-2}$$

To Find

Time period on Earth $= T_e = ?$

Time period on Moon $= T_m = ?$

Calculation:

As we know that

$$T_e = 2\pi\sqrt{\frac{\ell}{g}}$$

Putting values, we get

$$T_e = 2 \times 3.14\sqrt{\frac{1}{10}}$$

$$= 2 \times 3.14\sqrt{0.1}$$

$$= 2 \times 3.14 \times 0.3162$$

$$= 1.98 \text{ sec}$$

Or

$$\boxed{T_e = 2 \text{ sec}}$$

Similarly, the time period on Moon is

$$T_m = 2\pi\sqrt{\frac{\ell}{g_m}}$$

$$= 2\pi\sqrt{\frac{\ell}{g/6}}$$

$$T_m = 2\pi\sqrt{\frac{6\ell}{g}}$$

$$T_m = 2\times 3.14\sqrt{\frac{6}{10}}$$

$$T_m = 2\times 3.14\times\sqrt{0.60}$$

$$T_m = 2\times 3.14\times 0.7745$$

$$= 4.86\ \text{Sec}$$

or 4.9 Sec

$$T_m = \boxed{4.9\,\text{Sec}}$$

Result:
Time period of simple pendulum on the Earth surface is 2s and on the moon surface is 4.9 sec.

10.4 A simple pendulum completes one vibration in two seconds. Calculate its length when g = 10.0 ms^{-2}

(Board 2014,24) 10110120

Given data:

Time period of simple pendulum = T = 2s

Acceleration due to gravity = g = 10.0ms^{-2}

To Find:

Length of simple pendulum = ℓ = ?

Calculation:

As we know that

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

By taking square on both sides

$$(T)^2 = \left(2\pi\sqrt{\frac{\ell}{g}}\right)^2$$

$$T^2 = 4\pi^2\times\frac{\ell}{g}$$

$$\frac{T^2\times g}{4\pi^2} = \ell$$

Hence $$\ell = \frac{T^2\times g}{4\pi^2}$$

By putting the values we get

$$\ell = \frac{(2)^2\times(10.0)}{4\times(3.14)^2}$$

$$= \frac{4\times 10}{4\times 9.86}$$

$$= \frac{40}{39.44}$$

$$\ell = 1.02\ \text{m}$$

Result:
The length of simple pendulum is 1.02m.

10.5 If 100 waves pass through a point of a medium in 20 seconds, what is the frequency and time period of the wave? If wavelength is 6cm, calculate the wave speed.

(Board 2024) 10110121

Given data:

Number of waves passed = n = 100

Time taken = t = 20 sec

Wavelength = λ =6cm = 0.06m

To Find

Frequency = f = ?

Time Period = T = ?

Speed of Wave = v = ?

Calculation:

i) As we know that, the frequency of wave is, the number of waves passing through a point of medium in one second. Hence

$$\text{Frequency} = f = \frac{no.of\ waves\ passed}{time\ taken} = \frac{n}{t}$$

$$f = \frac{100}{20}$$

$$\boxed{f = 5Hz}$$

ii) As the time period 'T' is reciprocal of the frequency 'f' hence,

$$T = \frac{1}{f}$$

$$T = \frac{1}{5} = 0.2\,sec$$

$$\boxed{T = 0.2\,sec}$$

iii) According to the wave equation

$$v = f\lambda$$

$$v = 5\times 0.06$$

$$\boxed{v = 0.3\,ms^{-1}}$$

Result:

Frequency time period and wave speed is 5Hz, 0.2 sec. and 0.3 ms^{-1} respectively

10.6 A wooden bar vibrating into the water surface in a ripple tank has a frequency of 12 Hz. The resulting wave has a wavelength of 3cm. What is the speed of the wave? 10110122

Given data:

Frequency of wave = f = 12 Hz

Wavelength = λ = 3cm = 0.03m

To Find:

Speed of wave = v = ?

Calculation:

According to the wave equation

$$v = f\lambda$$
$$v = 12 \times 0.03$$
$$\boxed{v = 0.36ms^{-1}}$$

Result:

Thus, the speed of wave is $0.36ms^{-1}$.

10.7 A transverse wave produced on a spring has a frequency of 190 Hz and travels along the length of the spring of 90m, in 0.5s. 10110123

a. What is the time period of wave?

b. What is the speed of wave?

c. What is the wavelength of wave?

Given data:

Frequency of wave = f= 190 Hz

Distance travelled = d = 90m

Time taken = t = 0.5 sec

To Find:

i. Time period of wave = T = ?

ii. Speed of wave = v = ?

iii. Wavelength of wave = λ = ?

Calculation:

i) As we know that, the time period of wave is reciprocal of the frequency

Hence, $T = \frac{1}{f}$

$$= \frac{1}{190}$$
$$= 0.005\,sec$$
$$\boxed{T = 0.01\,sec}$$

ii) As we know that

$$Speed = \frac{distance\ travelled}{Time\,taken}$$
$$v = \frac{d}{t}$$
$$v = \frac{90}{0.5}$$
$$v = 180ms^{-1}$$
$$\boxed{v = 180ms^{-1}}$$

Result:

Wave speed is $18ms^{-1}$.

iii) According to the wave equation

$$v = f\lambda$$
$$180 = 190 \times \lambda$$
$$\frac{180}{190} = \lambda$$

Hence, $\boxed{\lambda = 0.95m}$

Result:

Wavelength of wave is 0.95m.

10.8 Water waves in a shallow dish are 6.0 cm long. At one point, the water waves move up and down at a rate of 4.8 oscillations per second. 10110124

(a) What is the speed of water waves?

(b) What is the time period of water waves?

Given data:

Wavelength = λ = 6.0cm = 0.06m

Frequency = f = 4.8 Hz

To Find

a) Speed of water wave = v = ?

b) Time period of water wave = T = ?

Calculation:

a) According to the wave equation

$$v = f\lambda$$
$$v = 4.8 \times 0.06$$
$$\boxed{v = 0.29ms^{-1}}$$

b) As the time period of wave is reciprocal to frequency of wave

Hence $T = \frac{1}{f} = \frac{1}{4.8}$

$$\boxed{T = 0.21\,sec}$$

Result:

The speed of wave is $0.29\ ms^{-1}$ and time period 0.21sec.

10.9 At one end of a ripple tank 80cm across, a 5 Hz vibrator produces waves whose wavelength is 40mm. Find the time the wave need to cross the tank. 10110125

Given data:

Distance = d = 80cm = 0.8m

Frequency = f = 5Hz

Wavelength = λ = 40mm $= \frac{40}{1000} = 0.04m$

To Find: Time to cross the tank = t = ?

Calculation:

According to the wave equation

$$v = f\lambda$$
$$= 5 \times 0.04$$
$$\boxed{v = 0.2ms^{-1}}$$

As we know that

$$d = v \times t$$

Hence, $t = \frac{d}{v} = \frac{0.8}{0.2} = 4\,sec$

$$\boxed{t = 4\,sec}$$

Result:

Time taken by the wave to cross the ripple tank is 4s.

10.10 What is the wavelength of the radio waves transmitted by an FM station at 90 MHz? Where 1MHz = 10^6Hz, and speed of radio wave is 3 x 10^8 ms^{-1}. 10110126

Given data:

Frequency = f = 90 MHz = 90 x 10^6 Hz

Speed = v = 3 x 10^8 ms^{-1}

To Find: Wavelength = λ = ?

Calculation: According to the wave equation

$$v = f\lambda$$
$$\frac{v}{f} = \lambda$$
$$\frac{3\times10^8}{90\times10^6} = \lambda$$
$$\lambda = \frac{3\times10^{8-6}}{90}$$
$$\frac{3\times10^2}{90} = \lambda$$
$$\frac{300}{90} = \lambda,\ 3.33m = \lambda$$

Hence, $\boxed{\lambda = 3.33m}$

Result:

Wavelength of the radio waves is 3.33m.